



# Intensity Frontier Overview

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# Snowmass Timeline

- The 2013 Community Summer Study is a 10-month process
  - » Began @ FNAL in mid October with Community Planning Meeting
  - » Pre-meetings began in earnest 1<sup>st</sup> week of January
  - » Dozens of pre-meetings have been held
  - » Last pre-meeting is EF on 1<sup>st</sup> July
  - » Minneapolis meeting July 29 – August 6

**Snowmass is almost over!!**

# Snowmass Timeline: IF events

- The 2013 Community Summer Study is a 10-month process
  - » Began @ FNAL in mid October with Community Planning Meeting
    - Held IF parallel session: not well attended by FNAL staff
  - » EDM Workshop @FNAL Feb 13-15
    - 77 participants, 29 from FNAL
  - » Neutrino pre-meeting @SLAC March 6,7
    - 97 participants, 6 from FNAL
  - » All-hands IF meeting @ANL April 25-27
    - 308 participants, 88 from FNAL
  - » Numerous phone meetings

# All Hands Intensity Frontier Meeting

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Particle  
Physics  
at the  
Intensity  
Frontier

## Intensity Frontier Workshop

25-27 April 2013 *Argonne National Laboratory*

US/Central Timezone

### Overview

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As part of the ongoing 2013 Community Summer Study ("Snowmass") the Intensity Frontier working group will hosted an all-hands workshop on April 25-27, 2013 at Argonne National Laboratory. This workshop will directly follow a writers meeting of the [Project X Physics Study](#) which was held at Fermilab on April 24, 2013.

### **Charge for the April 2013 Intensity Frontier Workshop**

Develop a coherent and interconnected view of the Intensity Frontier that will be presented at Snowmass. Describe future facilities and experiments at the Intensity Frontier and their capabilities. Document the contributions of the Intensity Frontier towards addressing the major questions in particle physics and explain how and why it is complementary to the other frontiers, which together constitute experimental particle physics. Leave the workshop with a clear understanding of what the approach will be at Snowmass 2013.

The Intensity Frontier working group is charged with summarizing the current state of knowledge, and identifying the most promising future opportunities at the Intensity Frontier. The working groups and their conveners are:

**IF1: Quark Flavor Physics** (Joel Butler, Zoltan Ligeti, Jack Ritchie)

**IF2: Charged Lepton Processes** (Brendan Casey, Yuval Grossman, David Hitlin)

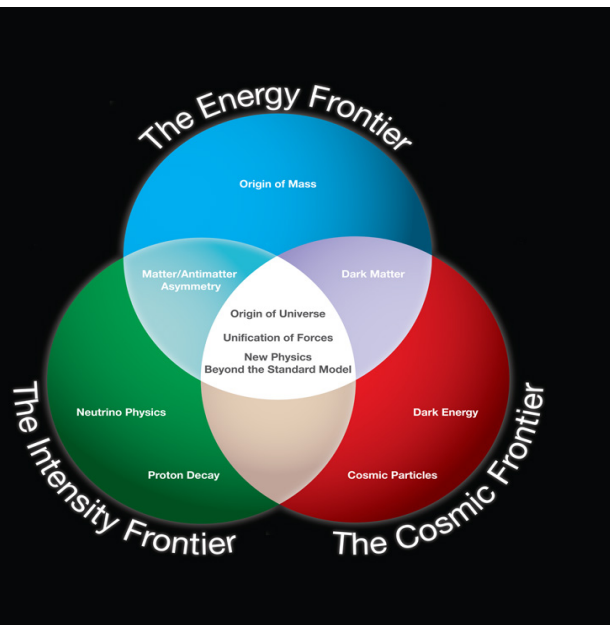
**IF3: Neutrinos** (Andre DeGouvea, Kevin Pitts, Kate Scholberg, Sam Zeller)

**IF4: Baryon Number Violation** (K.S. Babu, Ed Kearns)

**IF5: New Light, Weakly Coupled Particles** (Rouven Essig, John Jaros, William Wester)

**IF6: Nucleons, Nuclei, and Atoms** (Krishna Kumar, Zheng-Tian Lu, Michael Ramsey-Musolf)

# HEP and the Frontiers

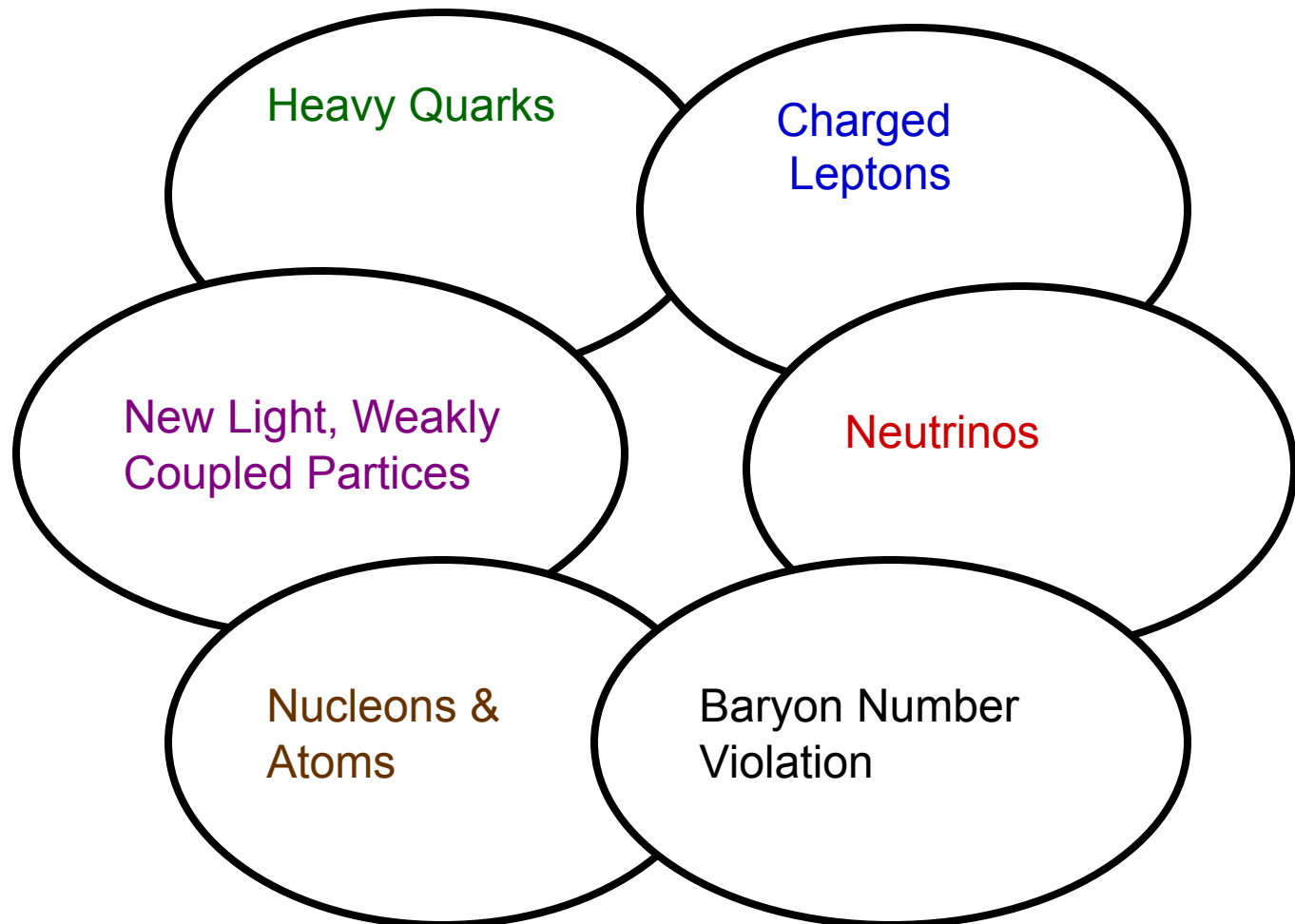


- **Concern about the stovepipes and lack of interaction between frontiers at the pre-meetings**
- **Interaction amongst frontiers must be main theme of Minneapolis Snowmass**

**Quote from Harry: “Respect for others and their work is the magic word we need for Snowmass”**

# The Intensity Frontier Program

**The Intensity Frontier is a broad and diverse, yet connected, set of science opportunities**



# CSS13 Working Groups

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## Quark Flavor Physics:

Joel Butler, Zoltan Ligeti, Jack Ritchie

K, D & B Meson  
decays/properties

## Charged Lepton Processes

Brendan Casey, Yuval Grossman, David Hitlin

Precision measurements  
with muons, taus

## Neutrinos

Andre deGouvea, Kevin Pitts,  
Kate Scholberg, Sam Zeller

All experiments for properties of  
neutrinos. Accelerator & non-accel.

## Baryon Number Violation

Kaladi Babu, Ed Kearns

Proton decay, Neutron Oscillation

## New Light, Weakly

## Coupled Particles

Rouven Essig, John Jaros, William Wester

“Dark” photons, paraphotons,  
axions, WISPs

## Nucleons, Nuclei & Atoms

Krishna Kumar, Z.-T. Lu, Michael Ramsey-  
Musolf

Properties of nucleons, nuclei or  
atoms (EDM), as related to HEP

# Liasons to Other Groups

Trying to build a matrix!

- **Frontier Capabilities:** Gil Gilchriese, Bob Tschirhart
- **Instrumentation Frontier:** matrix of coordinators for various detector subsystems listed at <http://www.hep.anl.gov/cpad/matrix.html>
- **Computing Frontier:** Brian Rebel, Mayly Sanchez, Stephen Wolbers

# Intensity Frontier Science

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The Intensity Frontier addresses fundamental questions:

**Are there new sources of CPV?**

**Is there CPV in the leptonic sector?**

**Are  $\nu$ 's Majorana or Dirac?**

**Do the forces unify?**

**Is there a weakly coupled Hidden Sector linked to Dark Matter?**

**Are apparent symmetries (B,L) violated at high scales?**

**What is the flavor sector of new physics?**

**Can we expand the new physics reach of the energy frontier?**

# The Intensity Frontier Manifesto



All frontiers of high energy physics aim to discover and understand the constituents of matter and their interactions at the highest energies, at the shortest distances, and at the earliest times in the Universe. The Standard Model fails to explain all observed phenomena: new interactions and yet unseen particles must exist. They may manifest themselves either directly, as new particles, or by causing Standard Model reactions to differ from often very precise predictions. The Intensity Frontier explores these fundamental questions by searching for new physics in processes extremely rare or those forbidden in the Standard Model. This requires the greatest possible beam intensities, as well as massive ultra-sensitive detectors. Many of these experiments are sensitive to new physics at higher mass scales, or weaker interaction strengths, than those directly accessible at the LHC or any foreseeable high-energy collider, thus providing opportunities for paradigm-changing new discoveries complementary to Energy and Cosmic Frontier experiments.

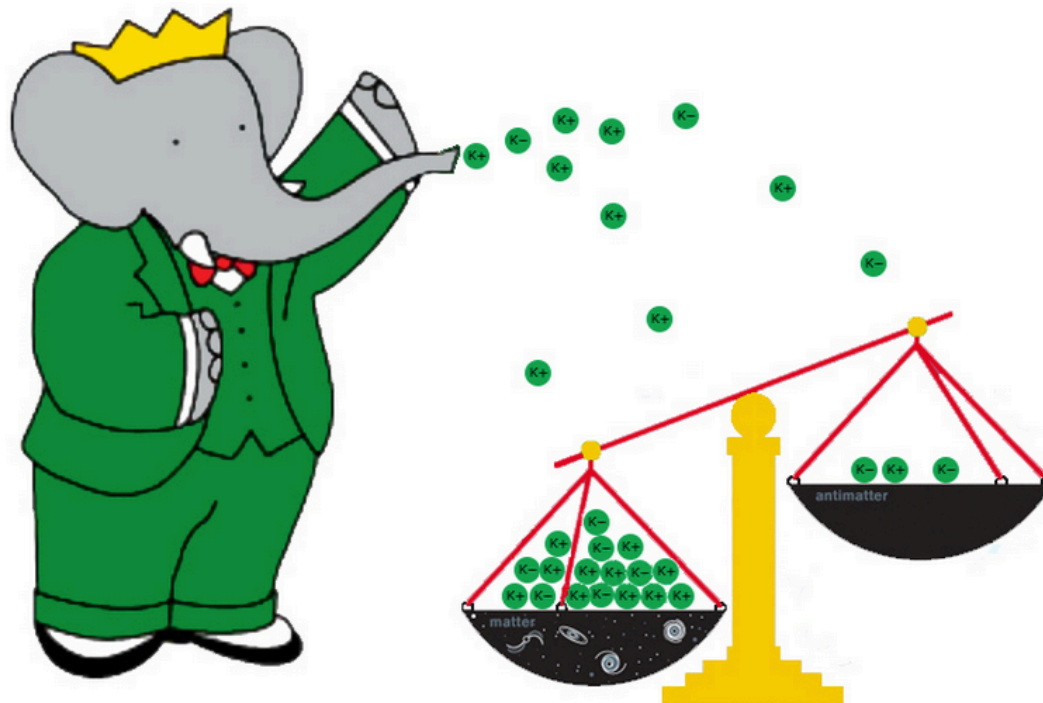
The range of experiments encompassing the Intensity Frontier is broad and diverse. Intense beams of neutrinos aimed over long distances at very large detectors will explore the neutrino mass hierarchy, search for CP violation and non-standard interactions, and increase sensitivity to proton decay. Multi-ton-scale detectors will determine whether neutrinos are their own antiparticles. Intense beams of electrons will enable searches for hidden-sector particles that may mediate dark matter interactions. Extremely rare muon and tau decay experiments will search for violation of charged lepton quantum numbers. Measurements of intrinsic lepton properties, such electric and magnetic dipole moments are another promising thrust. Rare and CP-violating decays of bottom, charm, and strange particles, measured with unprecedented precision, will be important to unravel the new physics underlying discoveries at the LHC. In any new physics scenario, Intensity Frontier experiments with sensitivities to very high mass scales will be a primary tool for exploration.

**Maybe we need something more crisp...**

# The IF Message

## Two main Themes:

1. Explore Symmetry Violation in Nature
  - CP, Baryon, Lepton Number Violation



## Two main Themes:

1. Explore Symmetry Violation in Nature
  - CP, Baryon, Lepton Number Violation
2. Explore High Energy Scales
  - IF explores very, very, very high energies!

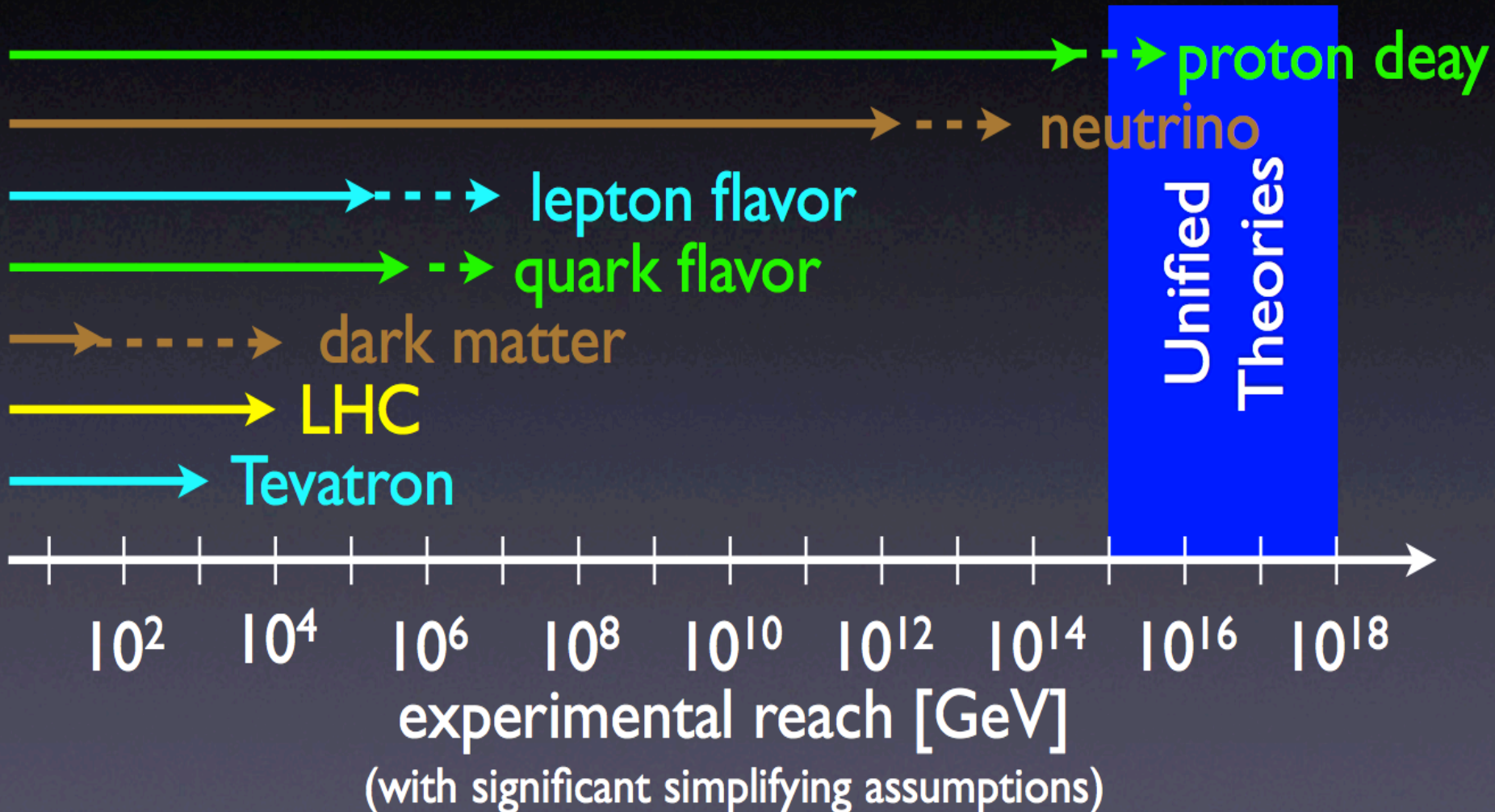
Flavor Physics:

$$A = A_0 \left[ c_{\text{SM}} \frac{1}{M_W^2} + c_{\text{NP}} \frac{1}{\Lambda^2} \right]$$

Neutrinos:

$$\frac{1}{\Lambda} (y_\nu LH)(y_\nu LH) + h.c. \quad \Rightarrow \quad \frac{y_\nu^2 v^2}{\Lambda} \bar{\nu}_L \nu_R^c.$$

# Power of Expedition



courtesy Zoltan Ligeti

# The IF t-shirt

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Thanks to  
David Hitlin

# Intensity Frontier Plan for “Snowmass”

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## Develop strategy to be a global leader

- **Programs for this decade:**
  - Focus of Rockville workshop report
  - Well established with g-2,  $\mu 2e$ , Nova, LBNE,  $\mu$ BooNE, EXO/Cuore, HPS, Super-KEKB, LHCb
- **Programs for next decade**
  - Focus for “Snowmass” study
  - Fresh ideas always encouraged! We need the very best ideas for new experiments
  - Want to develop world leading Intensity Frontier program
  - Demonstrate importance of Intensity Frontier science

# Draft Block Program for Snowmass

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| Time            | 29 July         | 30 July  | 31 July | 1 Aug | 2 Aug | 3 Aug | 4 Aug | 5 Aug           | 6 Aug |
|-----------------|-----------------|--|---------|-------|-------|-------|-------|-----------------|-------|
| morning         | Grand Plenaries | Subgroup Parallel Sessions and Joint Parallel Sessions |         |       |       |       |       | Grand Plenaries |       |
| early afternoon |                 | Subgroup Parallel Sessions and Joint Parallel Sessions |         |       |       |       |       |                 |       |
| late afternoon  |                 | Grand Plenary Sessions and Discussions                 |         |       |       |       |       |                 |       |
| evening         |                 | Parallel DISCUSSIONS                                   |         |       |       |       |       |                 |       |

Part of IF Snowmass plan is to educate others about IF physics

# Snowmass Report Hierarchy

- Individual contributions
  - » Anyone may submit a contribution!
  - » Everyone is encouraged to submit a contribution!
- Working group reports ~30 pages
  - » Authorship is anyone who has contributed to the report
- Frontier working group reports ~30 pages
  - » Anyone who has contributed to an IF document will be an author
- Snowmass Summary Report ~30 pages
  - » Definition of authorship is above Harry & JoAnne's paygrade

# How to Submit an Individual Contribution

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- <https://www-public.slac.stanford.edu/snowmass2013/>



SLAC NATIONAL ACCELERATOR LABORATORY

Snowmass 2013

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## Snowmass 2013 - Contributed Papers

We encourage any group or individual with interest in the future of high-energy physics to submit a White Paper on any subject relevant to the study. We also encourage any person or group with new scientific results relevant to the Snowmass study to submit the writeup of their analysis.

- Submit to the arXiv
- Register @ Snowmass proceedings site and link arXiv number
- Revisions handled through the arXiv
- Deadline for contributions: 30 Sep, 2013

## Deliverables from Snowmass:

Time line

Each subgroup in each frontier will produce 30-50 page subgroup write-up

Draft by July 1

Each subgroup in each frontier will also produce a 5-6 page subgroup summary

Draft by start of Snowmass

Each frontier will combine subgroup summaries into ~30 page frontier write-up

Draft by start of Snowmass

Each frontier will also produce a 5-6 page frontier summary – base for final summary

Draft by end of Snowmass

The “Snowmass book” will consist of:

The 7 frontier summaries ( ~7x30 pages)  
Overall summary ( based on frontier summaries)

Draft by end of Snowmass + few days

Present at DPF2013

# How can FNAL help?

- Billion \$ class (or less) experiments generally write a book documenting the physics case
  - » Project X Physics Study: effort began June 2012, book planned for May 2013
  - » Public release needed well in advance of Snowmass
  - » LBNE Neutrino Book would be very useful IMHO
- Send as many people as allowed by DOE travel regulations to the Minneapolis meeting
- Have a strong UEC presence (IF university collaborators) at Minneapolis meeting
- Develop better websites to highlight IF physics
- Embrace the Rockville IF report
- Embrace science from all frontiers